

Models for ordinal outcomes using NIMH data

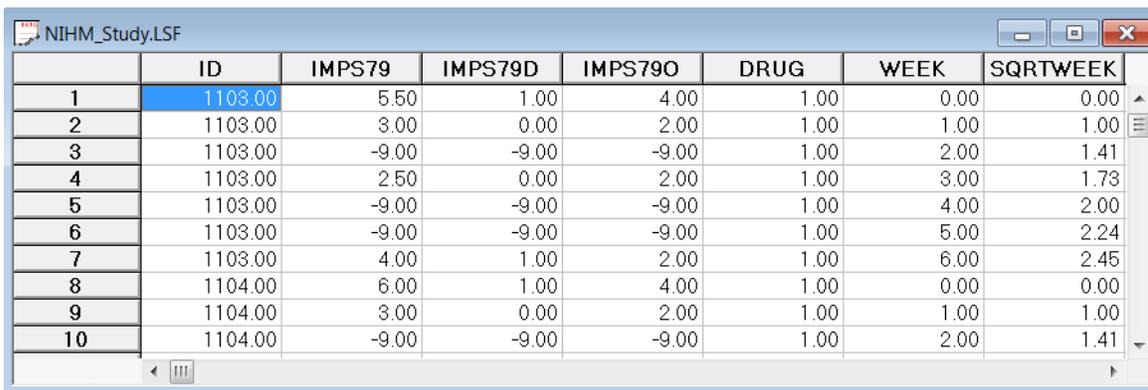
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1. Description of the NIMH data

To illustrate the application of the mixed-effects ordinal logistic regression model to longitudinal data, we examined data collected in the NIMH Schizophrenia Collaborative Study on treatment-related changes in overall severity. Specifically, Item 79 of the Patient Multidimensional Psychiatric Scale (IMPS; Lorr & Klett, 1966) was used. In this study, patients were randomly assigned to receive one of four medications: placebo, chlorpromazine, fluphenazine, or thioridazine. Since previous analyses (Longford, 1993, and Gibbons & Hedeker, 1994) revealed similar effects for the three anti-psychotic drug groups, they were combined in the present analysis. Finally, again based on previous analysis, a square root transformation of time was chosen to linearize the relationship of the IMPS79 scores over time.

Data for the first 10 observations are shown below in the form of a LISREL System File (LSF) spreadsheet file, named **nimh_study.lsf**.



	ID	IMPS79	IMPS79D	IMPS79O	DRUG	WEEK	SQRTWEEK
1	1103.00	5.50	1.00	4.00	1.00	0.00	0.00
2	1103.00	3.00	0.00	2.00	1.00	1.00	1.00
3	1103.00	-9.00	-9.00	-9.00	1.00	2.00	1.41
4	1103.00	2.50	0.00	2.00	1.00	3.00	1.73
5	1103.00	-9.00	-9.00	-9.00	1.00	4.00	2.00
6	1103.00	-9.00	-9.00	-9.00	1.00	5.00	2.24
7	1103.00	4.00	1.00	2.00	1.00	6.00	2.45
8	1104.00	6.00	1.00	4.00	1.00	0.00	0.00
9	1104.00	3.00	0.00	2.00	1.00	1.00	1.00
10	1104.00	-9.00	-9.00	-9.00	1.00	2.00	1.41

The variables of interest are:

- ID indicates the subject (437 patients in total).
- IMPS79 represents the original score on Item 79 of the Patient Multidimensional Psychiatric Scale. It was scored as: 1 = normal, or not at all ill; 2 = borderline mentally ill; 3 = mildly ill; 4 = moderately ill; 5 = markedly ill; 6 = severely ill; and 7 = among the most extremely ill.
- IMPS79D is a recoded version of the same scale, but in binary form, where scores up to, but excluding 3.5 were coded 0, and scores of 3.5 or higher were coded 1. The value "0" is associated with measurements classified as normal, borderline, mildly, or moderately mentally ill, while the value "1" was assigned to measurements corresponding to "markedly ill" through "most extremely ill."
- IMPS79O is also a recoded version of the same scale, but with the 7 original categories reduced to four: 1 = normal or borderline mentally ill, 2 = mildly or moderately ill, 3 = markedly ill, and 4 = severely or among the most extremely ill.
- DRUG indicates the treatment group, where 0 indicates the placebo patients, and 1 refers to the drug patients.
- WEEK represents the time during the course of the study when a specific measurement was made, and ranges between 0 and 6.
- SQRTWEEK is the square root of WEEK. This variable is generated within the LISREL spreadsheet.
- WSQRTxDR is the product of the treatment group and the square root of WEEK.

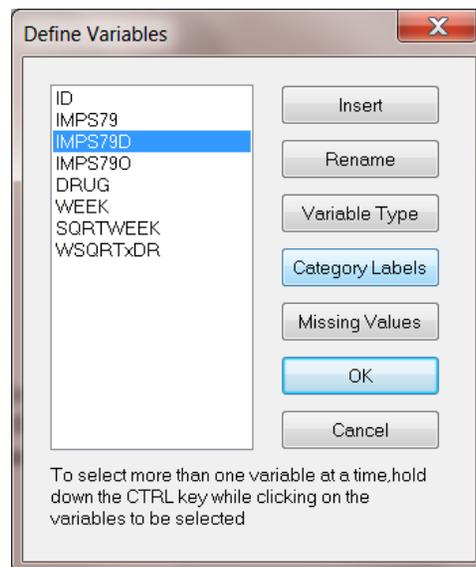
In this data file, each subject's data consist of seven lines, these being the repeated measurements on seven occasions. Notice that there are missing value codes (-9) for some subjects at specific time points. The data from these time points will not be used in the analysis, but data from these subjects at other time points where there are no missing data will be used in the analysis. Thus, for inclusion into the analysis, a subject's data (both the dependent variable and all model covariates being used in a particular analysis) at a specific time point must be complete. The number of repeated observations per subject then depends on the number of time points for which there are non-missing data for that subject. The specification of missing data codes will be illustrated in the model specification section to follow.

2. Defining variables

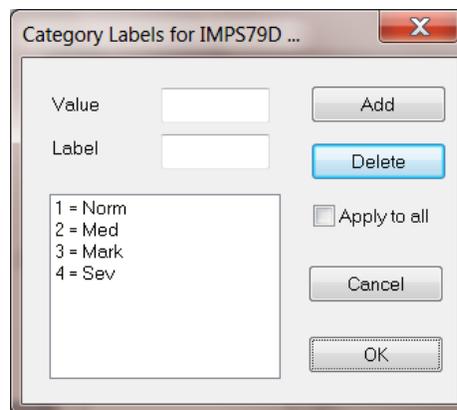
Defining column properties for the ordinal data is recommended. We use the column of IMPS79O as an example. First, highlight the column of IMPS79O by clicking on its header. Then right click and select the **Define Variables** option as shown below to open the **Define Variables** dialog box.

IMPS79O	DRUG	WEEK
4.0		.00
2.0		.00
-9.0		.00
2.0		.00
-9.00	1.00	4.00

Select variable IMPS79O as shown below to activate all the options on the **Define Variables** dialog box.



Click on the **Category Labels** option to activate the **Category Labels for IMPS79O** dialog box. Enter 1 in the **Value** box and corresponding **Label** of Norm, click on the **Add** button to add the first label for IMPS79O, with 1 = Norm. Similarly, add the next three labels: 2 = Mod, 3 = Mark, and 4 = Sev as shown below.



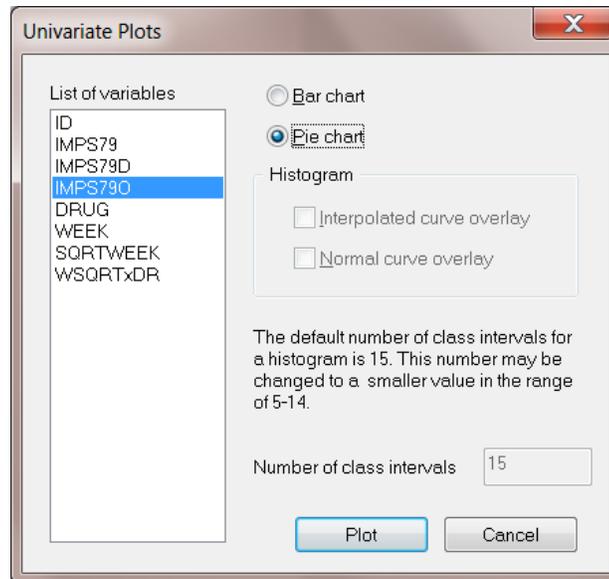
Click on the **OK** button to return to the **Define Variables** dialog box. Click on **OK** button to return to the LSF window. Save the change to the data set by clicking on the **File, Save** option.

3. Univariate graphs

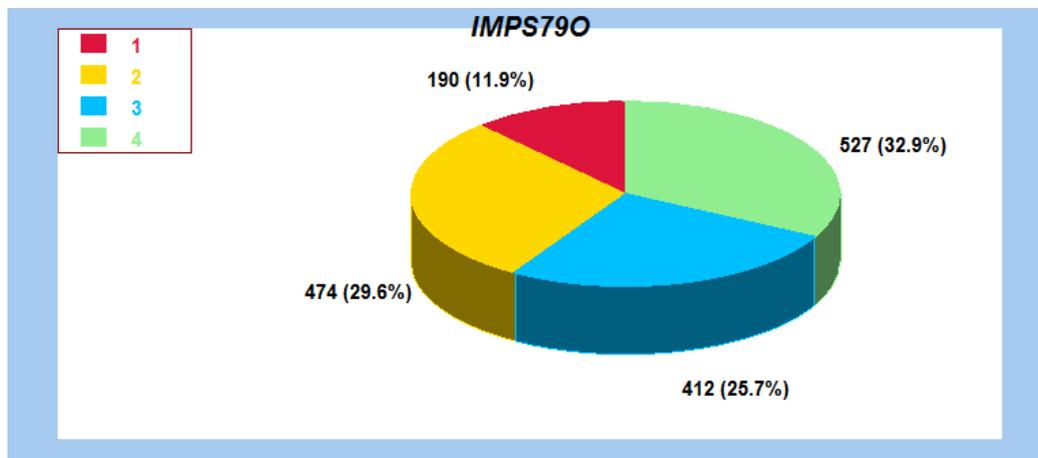
As a first step, we take a look at the ordinal variable IMPS79O which is the potential dependent variable in this study.

Pie chart

To generate a pie chart for IMPS790, first open the **nimh_study.isf** spreadsheet. Next, select the **Graphs, Univariate** option to load the **Univariate plot** dialog box. Select the variable IMPS790 and indicate that a **Pie Chart** is to be graphed as shown below.



Click the **Plot** button to display the following pie chart.

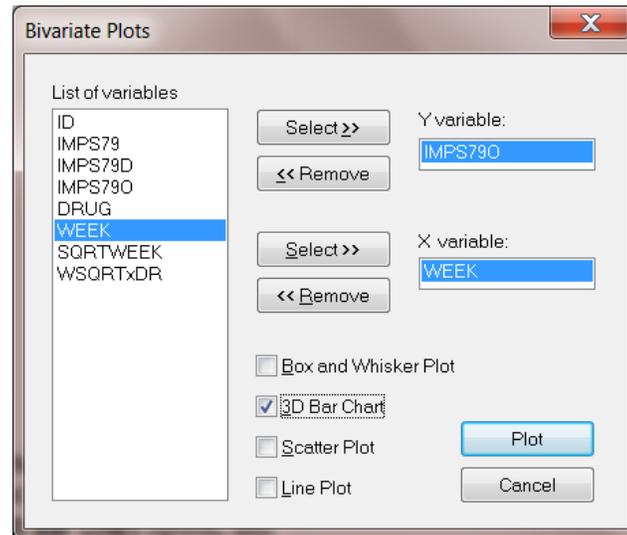


Note that most of the observations fall into the severe illness category. Keep in mind that the pie chart takes all observations, regardless of the time of measurement, into account. As such, it is informative about the distribution of all observed values of the potential outcome, but does not provide any information on possible trends in illness level over time.

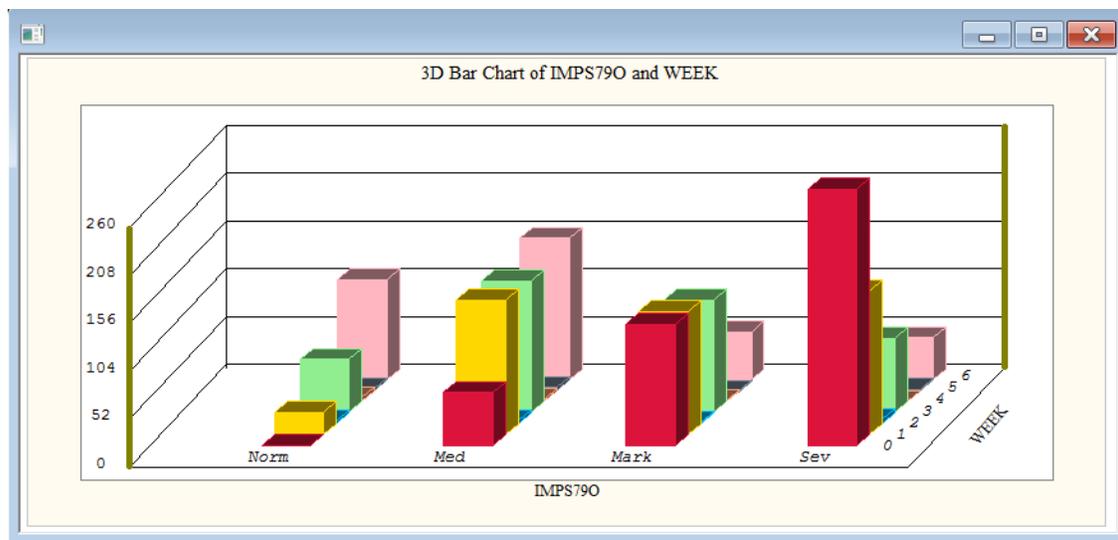
4. Bivariate graphs

It is hoped that the severity of the illness (IMPS790) will decrease over the treatment period. Before considering fitting a model to these data, we would like to explore the relationship between IMPS790 and WEEK using a bivariate bar chart.

Bivariate bar chart



A bivariate bar chart is accessed via the **Graphs, Bivariate** option on the **File** menu. The **Bivariate** dialog box is completed as below: select the outcome variable IMPS790 as the **Y**-variable of interest, and the predictor WEEK to be plotted on the **X**-axis. Check the **3D Bar Chart** option, and click **Plot**.



As shown above, most patients did not participate in the study at weeks 2, 4 and 5. At the beginning of the study (week 0), a large percentage of patients are markedly or severely ill. By the end of the study (week 6), most patients are reported as normal or moderate.